

FIELD STUDIES AND PARASITES OF *LIRIOMYZA*
TRIFOLIEARUM (DIPTERA: AGROMYZIDAE) IN
NORTHEASTERN USA

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Abstract.—*Liriomyza trifoliarum* Spencer, a native serpentine leafminer of alfalfa in the USA and Canada exists at low population densities. In 1978 the density averaged 0.2 mines per stem with a maximum of 1.3 mines per stem. It is controlled biologically (63% parasitism over a 4-year period) by 17 native parasite species plus 2 from Europe that recently were established against *Agromyza frontella* (Rondani). A list is provided of recovered parasite species and numbers of hosts parasitized by each species.

Liriomyza trifoliarum Spencer, a native serpentine leafminer that is not of economic importance, has been reported from Florida, California, and Prince Edward Island, Canada (Spencer, 1973). We found it on alfalfa throughout the northeastern USA and in Ontario, Canada; thus, its distribution is probably Nearctic on alfalfa. It also has been recovered from *Pisum sativum* L., *Trifolium incarnatum* L., and *T. repens* L. (Spencer, 1973). The present study was conducted in Delaware, south-central New Jersey, and southeastern Pennsylvania, coincidentally with studies of the alfalfa blotch leafminer (ABL), *Agromyza frontella* (Rondani), an imported European pest of alfalfa. The purpose of our study was to present basic observations on field populations of *L. trifoliarum* on alfalfa and compile a list of species of recovered parasites with numbers of parasitized hosts. The order, family, and identifier of species mentioned in this paper appear in Table 1.

In studying *L. trifoliarum*, we had difficulty separating its larvae or puparia from those of other agromyzid species infesting alfalfa: ABL, *L. trifolii*, and the vegetable leafminer, *L. sativae*. (*Liriomyza sativae* was never collected by us in the northeastern USA, but it was reported from Ohio (Spencer, 1973) and from greenhouses in Canada (McClanahan, 1978), from which it might escape.) We made no effort to separate these species by larval morphology, since many larvae were completely consumed by developing parasites. Agromyzid species were distinguished by mine type, frass distribution, and pupation habit (Table 2).

In both field and laboratory studies, we observed that *L. trifoliarum* always pupated in the leaflet. When isolated leaflets containing puparia were placed in tight-fitting petri dishes, the epidermis of the drying leaflet occasionally ruptured, and the puparium dropped out after formation. This is

Table 1. Order, family, and identifier of species mentioned in this paper.

Species	Species
HYMENOPTERA: BRACONIDAE	HYMENOPTERA: PTEROMALIDAE
<i>Dacnusa dryas</i> (Nixon) ^a	<i>Bubekia fallax</i> Gahan ^b
<i>Opius dimidiatus</i> (Ashmead) ^a	<i>Halticoptera circulus</i> (Walker) ^e
	<i>Halticoptera laevigata</i> Thomson ^e
HYMENOPTERA: EULOPHIDAE	DIPTERA: AGROMYZIDAE
<i>Achrysocharella formosa</i> (Westwood) ^c	<i>Agromyza frontella</i> (Rondani) ^d
<i>Chrysocharis clarkae</i> Yoshimoto ^e	<i>Liriomyza sativae</i> Blanchard ^d
<i>Chrysocharis giraulti</i> Yoshimoto ^e	<i>Liriomyza trifoliarum</i> Spencer ^d
<i>Chrysocharis pubicornis</i> (Zetterstedt) ^e	<i>Liriomyza trifolii</i> (Burgess) ^d
<i>Chrysocharis punctifacies</i> Delucchi ^e	
<i>Closterocerus cinctipennis</i> Ashmead ^b	
<i>Closterocerus tricornis</i> (Ashmead) ^b	
<i>Diauliniopsis callichroma</i> Crawford ^f	
<i>Diglyphus intermedius</i> (Girault) ^b	
<i>Diglyphus pulchripes</i> (Crawford) ^b	
<i>Diglyphus websteri</i> (Crawford) ^f	
<i>Pediobius bucculatricis</i> (Gahan) ^b	
<i>Pnigalio minio</i> (Walker) ^c	
<i>Zagrammosoma multilineatum</i> (Ashmead) ^b	

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perhaps what Spencer (1973, p. 99) referred to when he said, "Pupation appears to be variable, either in or outside the mine."

During 3 seasons (1975-77), we collected mined leaflets and recovered parasites at 7 fields (1 at Newark, DE; 3 near Oxford, PA; and 3 near Rancocas, NJ) by the method of Hendrickson and Barth (1979). The same procedure was followed in 1978 except the collection of 50 mined leaflets from each field was limited to *Liriomyza* spp. only, which were separated to species at the laboratory. In 1978, we also collected 20 alfalfa stems from each field and kept them fresh in a plastic bag in a car refrigerator. At the laboratory, the mines of ABL, *L. trifoliarum*, and *L. trifolii* were counted, disregarding the condition of the mining larvae. The ratio of mines of ABL:*L. trifoliarum*:*L. trifolii* was ca. 1800:40:1. *Liriomyza trifolii* was first found in mid-July 1978, on late 2nd-cutting alfalfa, and thereafter infrequently through October. It was probably present before July, but we did not encounter it, perhaps because the density was extremely low.

The average season-long density of *L. trifoliarum* was 0.2 mines/stem; maximum density was 1.3 mines/stem. If a leaflet was mined, we usually

Table 2. Some characteristics for distinguishing species of Agromyzidae found on alfalfa in northeastern USA.

Species	Mine type	Frass distribution	Pupation site
<i>Agromyza frontella</i>			
1st and 2nd instars	linear	broad strips	
3rd instar	blotch	broad strips	soil
<i>Liriomyza trifoliarum</i>	serpentine	isolated lumps	leaflet
<i>Liriomyza trifolii</i>	serpentine	narrow strips	soil
<i>Liriomyza sativae</i> ^a	serpentine	narrow strips	soil

^a A species which was potentially collectible, but that we never found in this area.

found 1 mine/leaflet; the maximum was 4 mines/leaflet. We found *L. trifoliarum* first in late May ca. 7–10 days after the first appearance of ABL mines and often in the same leaflet as ABL larvae. This was not surprising, since ABL larvae may mine >50% of the leaflets in a field at peak infestations.

Liriomyza trifoliarum makes feeding perforations through either the upper or lower leaflet epidermis. These perforations are angled rather than perpendicular, and do not penetrate to the opposite epidermis. When viewed against the sky, they appear light green. In contrast, ABL feeding perforations are always made through the lower leaflet epidermis, are perpendicular, and penetrate to or through the upper leaflet epidermis, giving the impression of clear "pinholes" when viewed against the sky.

Liriomyza trifoliarum pupates in the alfalfa leaflet. Thus at each harvest, some puparia are removed from the field. However, we think that most of the puparia remain in the field on the soil in dehiscent leaflets. Nearly all leaflets have dropped from the lower half of stems by harvest because of senescence. Any puparia in these leaflets are on the soil. Some puparia in leaflets on the upper half of the stem are also on the soil, according to our observation that leaflets mined by agromyzids dehisce before adjacent undamaged leaflets. This inclination is exacerbated during rainy weather, when moisture accelerates development of secondary plant pathogens in mines, and rain and wind cause mechanical dehiscence.

Parasitism of *L. trifoliarum* in 1978 was: 1st cutting, 28% (131 live forms); 2nd cutting, 38% (373 live forms); 3rd cutting, 74% (188 live forms); and post-3rd cutting, 79% (577 live forms). (Live forms are leafminer larvae or puparia that produce either adult *L. trifoliarum* or parasites.) For the 4 sampling periods, parasitism averaged 55% and totaled 62% (1,269 live forms). For the 4 seasons (1975–78), total parasitism was 63% (2,291 live forms); the parasite species and numbers of parasitized hosts appear in Table 3. To our knowledge, these were all primary parasites.

Table 3. Parasite species and numbers reared from *Liriomyza trifoliarum* collected in Delaware, southern New Jersey, and southeastern Pennsylvania, 1975-78.

Species	Recovered from		Number of hosts ^a
	Larva	Pupa	
<i>Diglyphus intermedius</i>	×		372
<i>Opius dimidiatus</i>		×	266
<i>Chrysocharis clarkae</i>	×	×	202
<i>Chrysocharis giraulti</i>	×	×	183
<i>Diglyphus pulchripes</i>	×		91
<i>Halticoptera circulus</i>		×	40
<i>Halticoptera laevigata</i>		×	30
<i>Phygadeuon minio</i>	×		30
<i>Closterocerus trilineatus</i>	×		28
<i>Diaulopsis callichroma</i>	×		28
<i>Achrysocharis formosa</i>	×		22
<i>Closterocerus cinctipennis</i>	×		21
<i>Diglyphus websteri</i>	×		14
<i>Pebidiopsis bucculatricis</i>		×	6
<i>Chrysocharis punctifacies</i> ^b		×	4
<i>Dacnusa dryas</i> ^b		×	3
<i>Bubekia fallax</i>		×	2
<i>Chrysocharis pubicornis</i>		×	2
<i>Zagrammosoma multilineatum</i>	×		1
Unidentifiable ^c			94
		Total	1,439

^a Occasionally more than 1 parasite emerged from a host.

^b Introduced European species released against *Agromyza frontella*.

^c Adults were damaged or lost, or larvae were in diapause.

The European parasites *Dacnusa dryas* and *Chrysocharis punctifacies*, established in 1978 against ABL in Delaware (Hendrickson, 1978), were both recovered from *L. trifoliarum* in 1978. Thus this serpentine leafminer, found throughout the range of ABL, may serve as an effective alternate host in the biological control of ABL.

Although we never observed predation, we found indirect evidence of it. One or more small, round punctures through the leaflet epidermis over the integumental remains of *L. trifoliarum* larvae suggested that one or more of the hemipteran predators that are found on alfalfa had fed on the larvae. These punctures were distinctly different from feeding perforations made by adult female agromyzids.

Hendrickson and Barth (1979) reported that 12 of the 14 species of native parasites that attack ABL were derived from native *Liriomyza* spp. on alfalfa. These 12 species were all recovered from *L. trifoliarum*, and some were recovered from *L. trifolii*. In 1978, we recovered a single individual of a 13th species, *Zagrammosoma multilineatum*, from *L. trifoliarum*. The

finding that in 1978 the larval population of *L. trifoliarum* was ca. 40 times that of *L. trifolii* indicated that the native parasite complex that attacked ABL was derived almost entirely from the parasites of *L. trifoliarum*.

Our data indicated that *L. trifoliarum* is not of economic importance on alfalfa in the northeastern USA and Canada because it is kept at low population densities by 19 species of parasites and one or more species of predator.

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